Proving that green lasers are greener

A collaboration of the laser specialist TRUMPF, the Fraunhofer Institute for Laser Technology ILT, and the Helmholtz-Zentrum Hereon used PETRA III to find a better laser welding process for copper metal-ceramic welds in electric vehicles.

INTRODUCTION

Electromobility poses major challenges for laser technology. Copper is the most important material for the manufacturing of core e-mobility components. A key process is welding copper onto metal ceramic substrates: on a thin layer of copper on top of a ceramic plate, another copper piece is welded onto the top copper layer. These parts of the power electronics are used in high voltage surroundings like the battery as conductive connectors, and hence need to be reliable and durable. For an optimized laser welding process, the copper layers should be as thin as possible, the welding process should be as fast as possible, and the laser should not interfere with the ceramic substrate.

Copper absorbs only about 5 per-cent of laser radiation in the near infrared range (NIR) and conducts heat well. Both properties lead to considerable welding problems: non-optimal weld depth, pore formation and spill development. The processes are, therefore, under scrutiny. In addition to NIR lasers, TRUMPF also has lasers with a green wavelength in its product range, which could be better suited for copper laser welding.

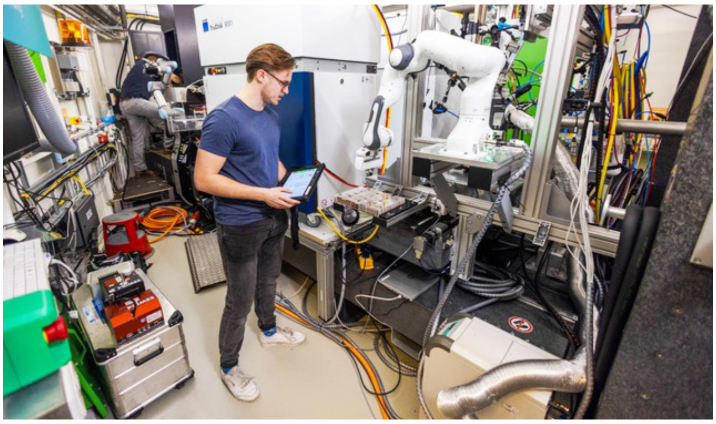

Image of the experimental set-up. The metal ceramic substrate lays on the sample holder, while a copper band is laser-welded on it. The laser is located on top of the sample and aimed at the copper band.

TRUMPF Fraunhofer ILT Helmholtz-Zentrum hereon DESY.

METHOD

The team used x-ray videography to study the effect of the wavelength of the laser radiation on the welds. The welding laser impinges onto the sample from the top, and the synchrotron radiation transmits the sample from the side through the welding region onto a scintillator. Due to the radiation, the scintillator begins to glow. This glow is then captured with a high-speed camera to produce videos of the welding process in high spatial and temporal resolution. An exemplary suitable set-up can be found in the experimental hutch of the beamline P07, operated by Helmholtz-Zentrum Hereon.

INSIGHTS AND ANALYSIS

While conventional methods would only observe the plasma's electromagnetic emissions, the brilliant synchrotron radiation allowed the collaborators to investigate inside the melt, and the melt dynamics. Over one hundred experimental runs with the NIR and green laser were used to make videos of the welding process, to study pore and splatter formation in the weld joints. The heat's effect on the sensitive electronic parts in the vicinity of the weld was also of interest.

BENEFITS

The experiments at PETRA III reveal how to improve welding copper on a metal-ceramic substrate, a crucial process in e-vehicles. The welding process is optimized using a green laser, due to the better absorption of green wavelengths by copper. The melting point of copper is reached faster, leading to a faster and more controllable welding process. Welding now requires less lasing power and produces fewer rejected welds, saving energy and raw resources for manufacturers.

"A few weeks after the experiments, we could already transfer the results into practice. This is how we found the fastest and best laser welding processes for copper joints of all types."

Dr. Mauritz Möller
Automotive Industry Management at TRUMPF

For more information please contact:

Deutsches Elektronen-Synchrotron DESY
Ein Forschungszentrum der Helmholtz-Gemeinschaft
Notkestraße 85 I 22607 Hamburg

DESY Innovation & Technology Transfer:
Dr. Sabine Brock
E-mail: sabine.brock@desy.de
Phone: +49 40 8998-4579
www.innovation.desy.de